A Daily Simulation Model of the California Natural Gas Transportation and Storage Network

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CEC Workshop
November 15, 2007

Features of the Model

- Network model
- Perfect foresight with seasonality
- Multilayered model
  – Engineering constraints
  – Regulatory constraints
- Focus on intrinsic value of storage
- Focus on indirect effects
- Focus on simulation rather than forecast
- Base Case calibration: April 2006-March 2007

Temporal and Spatial Dimension

Temporal dimension

52 weeks & 52 weekends

It captures seasonality and weekly cycles

The year is defined as a storage year: April-March

Spatial dimension

2 demand regions

5 supply regions

11 pipeline routes

4 storage facilities

It is a California model but accounts for links with other parts of the North American network

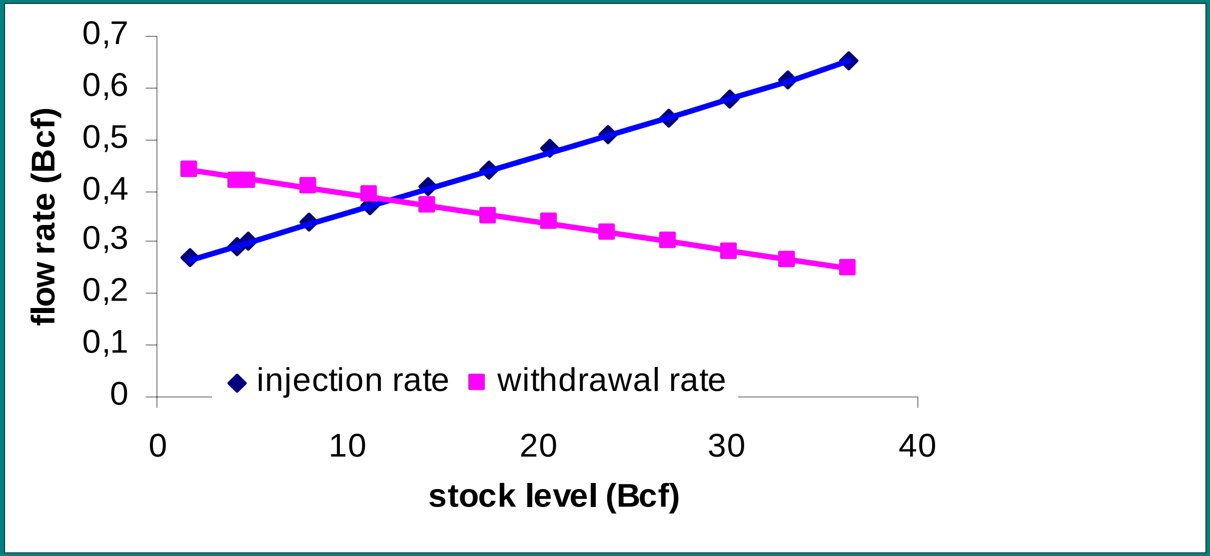
Seasonality and weekly cycles upstream affect the quantity of gas that comes to California (*residual supply*) from each producing region each period.

Storage Activity

<u>Technical considerations</u>:

Official storage capacity vs actual storage capacity

Stock- flow rate relationships for a hypothetical storage facility



<u>Regulatory constraints</u>:

Core inventory requirements for utilities

Utilities have exclusivity on core storage

Base Case Parameters

Discount rate = 4%

For any price, the quantity demanded during the weekend is 64% of the quantity demanded during the week

	PG&E core	PG&E noncore	PG&E elec.gen.	SoCalGas core	SoCalGas noncore	SoCalGas elec.gen.	Off-system elec.gen.
Price elasticity	-0.38	-0.33	-0.61	-0.38	-0.33	-0.61	-0.61
Weekend shifter (summer)	0.64	0.87	0.86	0.72	0.85	0.90	0.90
Weekend shifter (winter)	1.44	0.87	0.72	1.273	0.97	0.6	0.6

Supply	Canada	Rockies	San Juan	Permian
Price elasticity	0.45	0.31	0.94	0.48
Weekend shifter (summer)	1.075	1.11	1	0.925
Weekend shifter (winter)	0.85	0.87	1	1.14

Note: Supply and demand parameters were estimated econometrically using data from 2002 through 2006. The chosen elasticity values are either the estimated parameters or up to 3 standard deviations from the point estimate depending on which one resulted in the best base-case calibration

Base Case Calibration Results: Flows

Average base case flows to California by producing region

	Canada	Rockies	San Juan	Permian
Average summer weekday flow	1.62	0.93	1.59	0.62
Average summer weekend flow	1.68	1.28	1.43	0.40
Average winter weekday flow	1.23	1.22	1.89	0.85
Average winter weekend flow	0.53	0.74	1.93	1.12

Relative seasonality

-Upstream competition for Canadian gas is stronger in the winter (colder temperatures in Canada and Midwest than in California). → Flows to California are relatively higher in the summer.

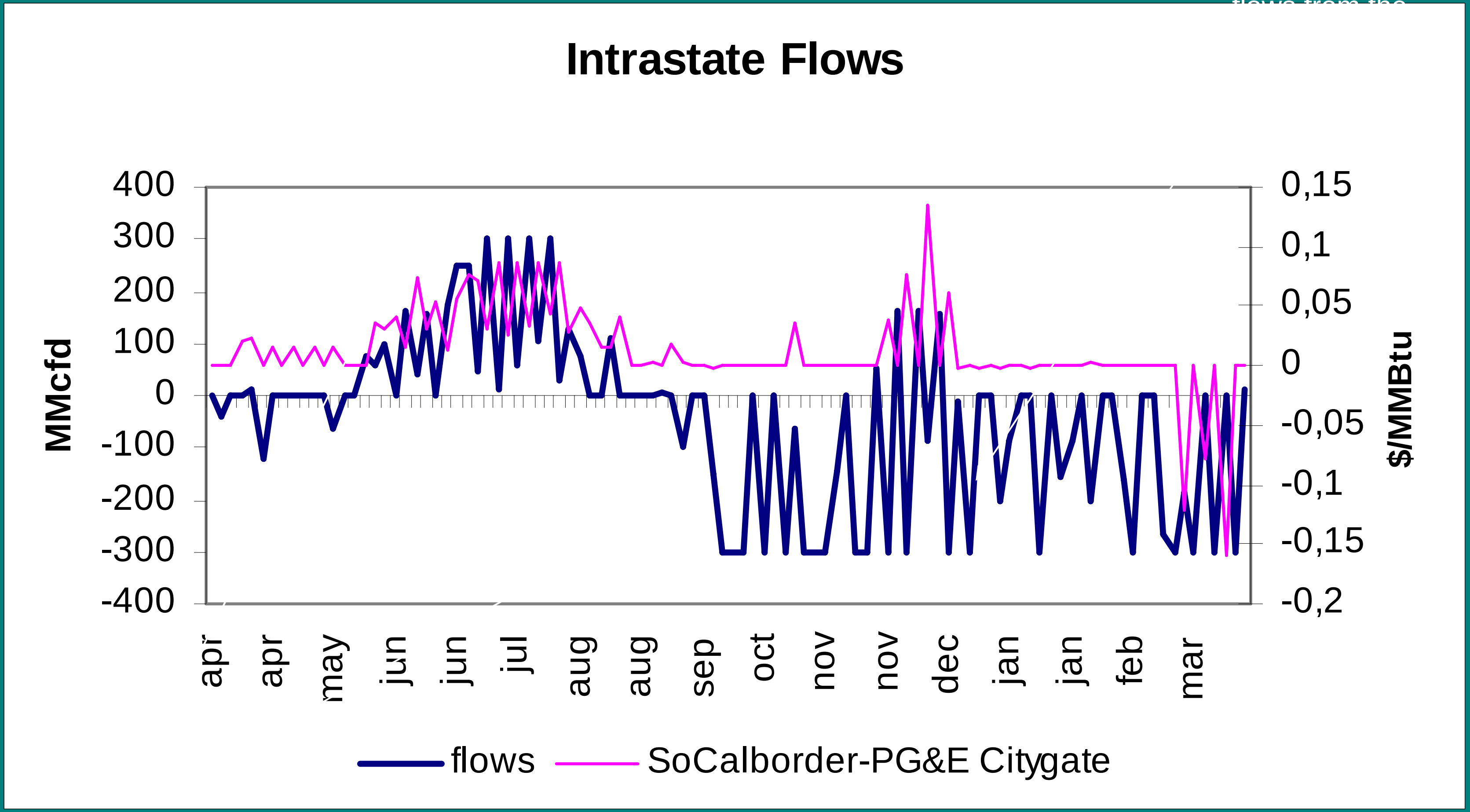
-Upstream competition for San Juan and Permian gas is stronger in the summer (warmer temperatures in Arizona and New Mexico than in California). →Flows to California are relatively larger in the winter

Weekly cycles

Upstream competing regions for Canadian and Rockies gas have very strong winter weekend demand (associated to residential heating) →Winter flows from northern producing regions to California are significantly smaller on weekends than weekdays.

Base Case Calibration Results: Intrastate Flows

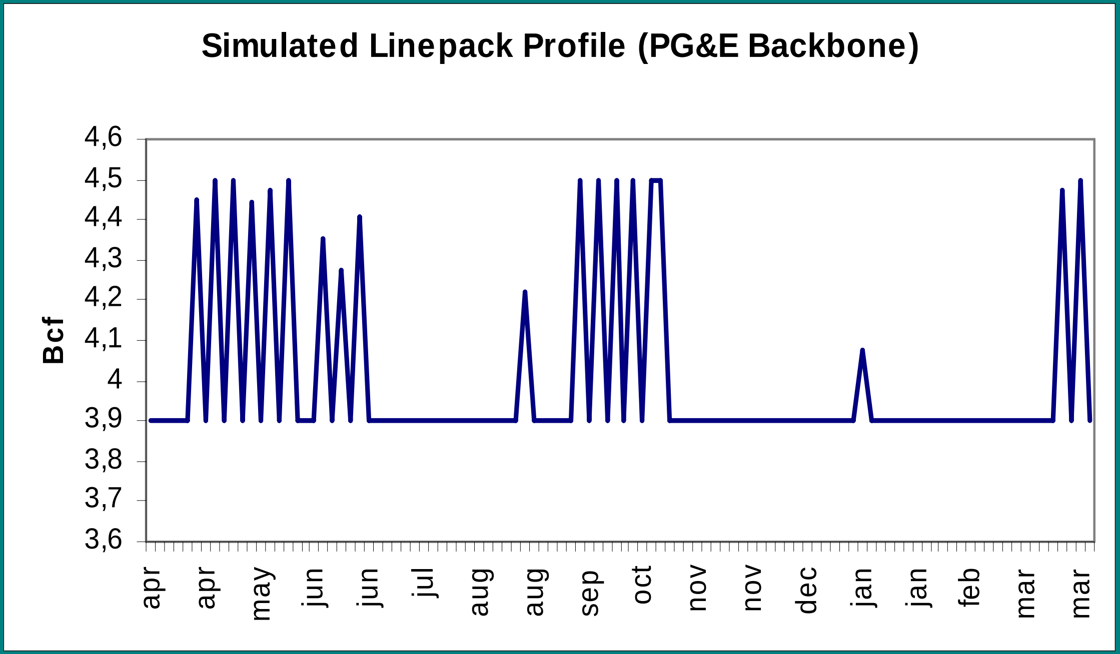
Negative flows are flows from the



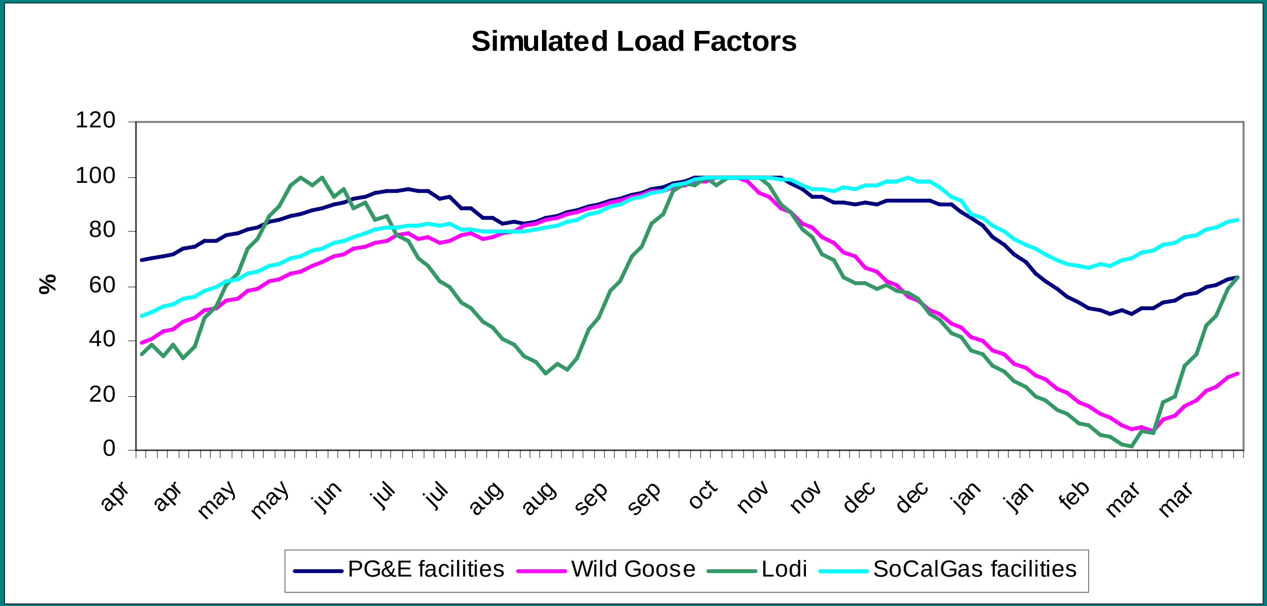
Intrastate flows change direction to take advantage of arbitrage opportunities in the south-north price differential

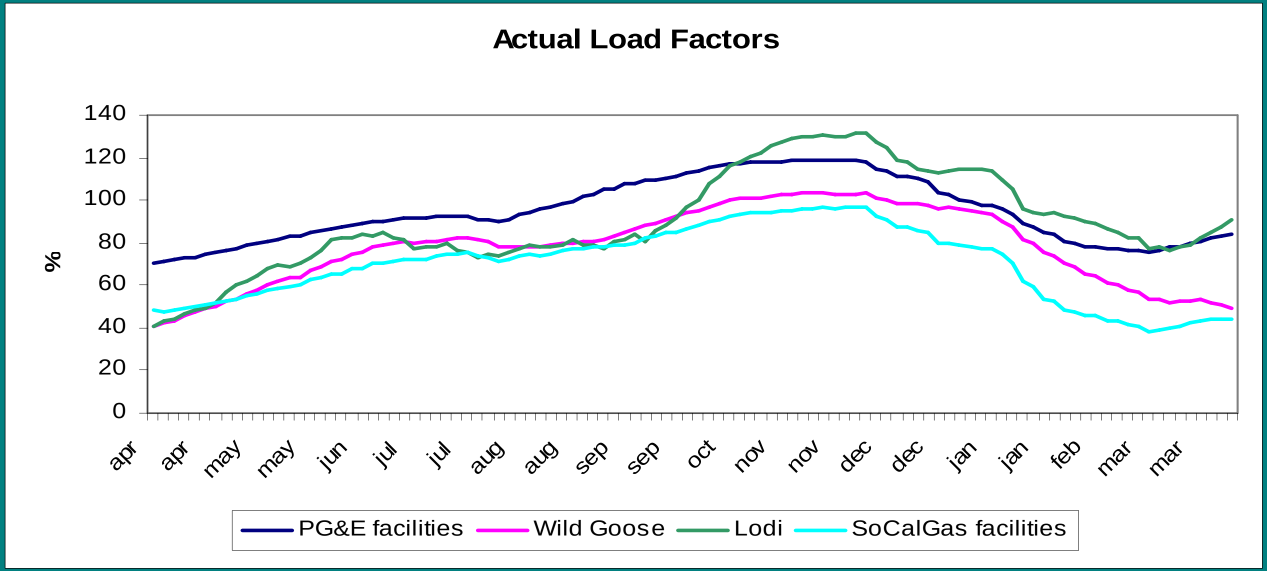
Base Case Calibration Results: Linepack

- Simulated summer linepack is built up during the weekend and drawn down Monday through Friday
- Simulated winter linepack is at lower bound most of the time. It complements storage withdrawals
- Kern River displays more linepack fluctuations than the utility backbone pipelines



Base Case Calibration Results: Storage Profiles





Fully utilized storage capacity by the end of the injection season

Simulated April-January spread = 1.16 $/MMBtu

Scenario 1: LNG from Baja California

-New supply node: Regasification facility in Baja California

-1 Bcfd

-Interconnection at Otay Mesa

Assumptions about residual supply:

Reference price= average of Australia and Indonesia export price

Reference quantity= 75% load factor in summer; 50% in winter

No weekly cycle expected for LNG shipments

Price elasticity= 0.93

Results for LNG Scenario

Change in supply profiles

Change in flows w.r.t. base case	Canada	Rockies	San Juan	Permian	Total
Summer weekday	-7%	-11%	-11%	-16%	2%
Summer weekend	-3%	-7%	-11%	-30%	2%
Winter weekday	-9%	-4%	-3%	-6%	4%
Winter weekend	-41%	-14%	-4%	-4%	5%

Change in intrastate flows

Increase in the frequency and volume of flows shipped in the south to north direction

Changes in storage profiles

All facilities are filled by October 31 and winter withdrawals are smaller

Changes in citygate prices

Change w.r.t. base case	PG&E Citygate	SoCalborder
Summer	-4%	-5%
Winter	-2%	-3%

Final remarks

- Importance of network effects
  - Upstream demand profiles explained by weather or demand structure have a large effect on the supply profiles observed in California
- Natural gas storage and supply diversity are key to avoid deliverability problems for California if its demand peaks coincide with demand peaks upstream
- A California network model allows analyzing the dynamics of intrastate flows and north-south price differentials
- A continent-wide model would be needed to analyze feedback effects between California and producing regions or competing demand regions